


Neighborhood Schools and Sidewalk Connections

What Are the Impacts on Travel Mode Choice and Vehicle Emissions?

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In the next few decades, communities across the United States will have to accommodate substantial increases in student enrollment. The expected boom in school construction and renovation and the related planning decisions have implications for travel and for vehicle emissions.

The study reported here was the first to examine the relationship between school location, the built environment around schools, student travel to school, and the emissions impacts of this travel. Students with shorter walk and bike times to school proved significantly more likely to walk or bike—which argues for neighborhood schools. Students who have access to sidewalks along main roads were also more likely to walk—which argues for improvements in sidewalk networks.

Neighborhood schools that can be reached by walking and biking can increase the amount of walking and biking to school, can shorten trip distances, and can reduce motor vehicle emissions significantly.

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Size and Location Trends

Public schools have been increasing in size and drawing students from larger areas. Between 1940 and 1990, the total number of elementary and secondary public schools fell by 69 percent, despite a 70 percent increase in the U.S. population (*1*). Large new schools typically are placed in outlying areas, because sites are available and land prices are low.

Public policies have contributed to this trend (*2–4*). The funding formulas in many states favor new school construction over renovation. Minimum acreage standards for elementary, middle, and high schools may be met only at greenfield locations. Building codes designed for new construction are applied to older schools that could be renovated. School districts are often exempt from local planning and zoning laws and can site schools without consideration of local policies and plans.

Walking and Biking Trends

Paralleling the trend toward large schools at remote sites is the sharp decline in walking and biking to school. According to the recently released 2001 National Household Travel Survey, less than 15 percent of students between the ages of 5 and 15 walk to or from school, and only 1 percent bike. In 1969, the first Nationwide Personal Transportation Survey (NPTS) showed that 48 percent of students walked or biked to school (*5*).[1]

A recent survey by the Centers for Disease Control and Prevention (CDC) found that only 31 percent of children 5 to 15 years old who lived within 1 mile of school walked or biked (*6*). In 1969, the figure approached 90 percent (*5*).

Why the decline in walking and biking to school? In the CDC survey, parents cited long distances as the primary barrier (*6*). The supersizing of schools has left relatively few students living within comfortable walk-

[1] This figure applies to students in elementary and intermediate grades, the closest counterparts to the 5–15 age range reported for 2001.

ing or biking distance. Nonetheless, even short school trips are made by automobile, which indicates that other factors are at work.

The CDC survey found that danger from traffic was the second most important barrier to walking and biking to school (*6*). The absence of sidewalks is a risk factor for pedestrian accidents (*7-8*). A poor walking environment has been linked to dependence on the automobile by the general population and would be expected to discourage walking and biking to school (*9*).

Childhood Health Trends

Accompanying the decline in school walk and bike trips has been a general decline in physical activity and a rise in childhood obesity. National data indicate that nearly one-third of all American youth do not engage in sufficient amounts of vigorous or moderate physical activity (*10*).

In 1999–2000, 15 percent of U.S. children 6 to 11 years old and 16 percent of adolescents 12 to 19 years old were overweight. Since the 1960s, this statistic has nearly tripled for adolescents and quadrupled for 6- to 11-year-olds (*11*).

Walking and Biking

In response, many states and localities have launched Safe Routes to School programs[2]—California has led the way. The programs provide funding for sidewalks, bike lanes, and other infrastructure improvements to encourage walking and biking by schoolchildren. The U.S. Department of Health and Human Services and CDC have started a Kids-Walk-to-School Campaign, to counter the rising rates of childhood obesity, diabetes, and asthma.[3]

[2] www.dhs.ca.gov/epic/sr2s/

[3] www.cdc.gov/nccdphp/dnpa/kidswalk/

Photo: Dan Burden, Walkable Communities, Inc.

Neighborhood Schools

Policy makers are reemphasizing the value of small, in-neighborhood schools. New investments are coming from federal, state, and local governments, as well as from foundations focused on educational performance.

In fiscal year (FY) 2002, Congress appropriated $142 million for the Smaller Learning Communities program, up from $44 million in FY 2000, to help large high schools and school districts make schools smaller. The Bill and Melinda Gates Foundation has invested $1 billion over 5 years to create 1,500 new small high schools.

In July 2003, South Carolina eliminated its minimum acreage requirements for schools and granted waivers for school square footage to foster neighborhood schools. The Council of Educational Facilities Planners International has removed the high minimum-acreage requirements from its industry-standard school-siting guidelines (*12*).

Across the country, cities and school districts offer other compelling examples. In Milwaukee, the Neighborhood School Initiative is constructing six new schools, adding on to 19 schools, and renovating 15 schools. All schools remain in walkable neighborhoods, and more students can attend school in their own neighborhood.

In St. Paul, Minnesota, the newly renovated and expanded John A. Johnson Achievement Plus Elementary School is a compact, multistory building that allowed an increase in the number of playing fields. Additional buildings are planned to accommodate future student increases.

Wake County schools partnered with the City of Raleigh, North Carolina, to build the Moore Square Museums Magnet

Photo: Dan Burden, Walkable Communities, Inc.

Middle School on a four-acre block in an in-town neighborhood. The school won a National Award for Smart Growth Achievement from the U.S. Environmental Protection Agency (EPA) in 2003 and has drawn new residents and investments to its neighborhood.

Neighborhood School Advantages

Small neighborhood schools are said to

- Foster a better learning environment with higher student achievement,
- Promote neighborhood cohesion and pride,
- Discourage sprawl and preserve farmland,
- Lower busing costs and student parking requirements, and
- Encourage children to walk or bike to school (*2–4*, *13–14*).

School Mode Choice

Research that connects mode choice for the journey to school with characteristics of the built environment is sparse. The studies collectively suggest that children are more likely to walk or bike to small schools in walkable neighborhoods than to large schools in remote locations.

In one study, the percentage of students walking to school was found to be four times higher for schools built before 1983 than for those built later—an average of 16 percent walked to older schools compared with 4 percent to newer schools (*2*). A study of fifth-grade students at 34 California public schools showed that walking and biking rates were associated positively with neighborhood population density and negatively with school size, after controlling for the percentage of students on public welfare and for the percentage of ethnic minorities (*15*).

A study of school mode choice in California found that walking and biking to school were more likely for a household living within 1 mile of the school (*16*), and less likely for a household with licensed drivers who could provide rides. Some pedestrian-friendly design features had positive influences on walking and biking, such as the presence of street trees within one-quarter mile of the school. Other features, such as short blocks and mixed land uses, had negative influences.

Model Development

Travel demand modeling attempts to explain mode choice as a function of characteristics of trip origins and destinations, trip interchanges, and travelers. The literature suggests that mode choice for school trips also may depend on school location and accessibility, school size, and grade level.

The utility function in a school mode choice model, therefore, should include characteristics of trips, students, schools, and built environments at each end of the trip. Alternative multinomial and nested logit structures were estimated using maximum likelihood techniques.

Gainesville, Florida, was chosen as the study area. Two regional surveys including travel diaries offered a relatively large sample of trips to analyze. Moreover, many variables characterizing the built environment could be examined for their influence on mode choice.

The variables describing urban form were available at the traffic analysis zone level. The variables included overall density, the balance of jobs and residents, the job mix, the commercial floor area ratio, sidewalk coverage, bike lane and paved shoulder coverage, street tree coverage, and two regional accessibility measures (*17*). Table 1 reports mode of travel for the final sample of 709 school trips. Figures 1 and 2 illustrate the locations and the built environments of two Gainesville high schools with contrasting mode splits.

TABLE 1 Travel Modes for School Trips from Gainesville Surveys, Kindergarten Through 12th Grade

Mode	Count
Car	548
School Bus	105
Walk	32
Bike	24
Total	709

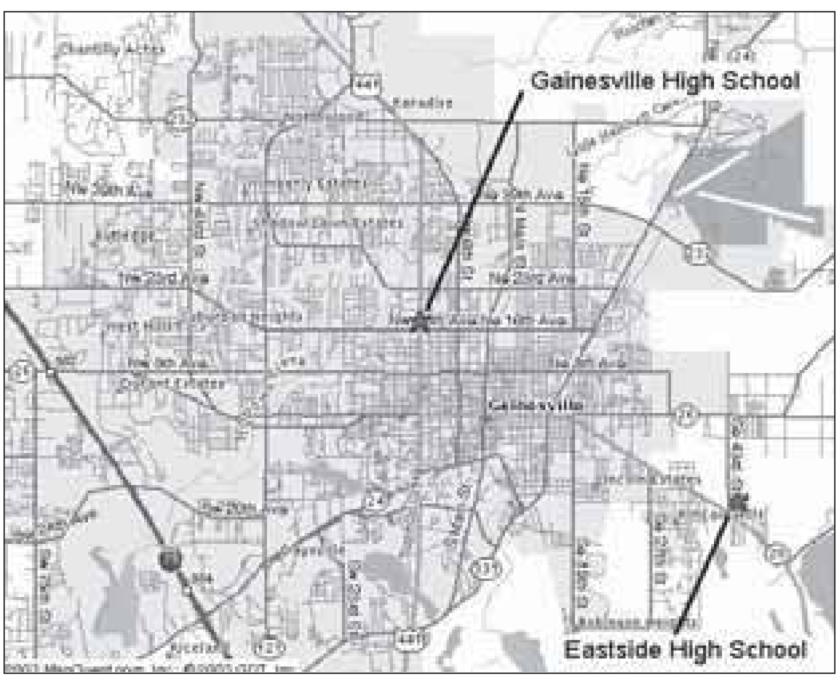

FIGURE 1 Location of sampled schools: Gainesville High School and Eastside High School.

(a) (b)

FIGURE 2 Aerial views of the sampled high schools (same scale), with data for sampled trips: (*a*) Gainesville High School: auto trips 38 (85%); walk trips 6 (13%); bike trips 1 (2%); average auto trip length: 4.24 miles; and (*b*) Eastside High School: auto trips 19 (100%); average auto trip length: 8.42 miles.

Model Results

The best-fit model is presented in Tables 2, 3, and 4. In Table 2, coefficient values and *t*-statistics indicate the effects of independent variables on mode choice probabilities.

In Table 3, the marginal effects of independent variables on mode choice probabilities are presented as elasticities. Elasticities summarize the relationships between travel outcomes and the explanatory variables. The values presented are point elasticities at the mean values of the independent variables.

Table 4 presents the results of simulations that lowered the values of each independent variable by 25 percent and computed new choice probabilities. The mode shares were computed by summing the probabilities and multiplying by the number of individuals. The difference between the original mode shares and the simulated mode shares represents the effect of changes in the variable on the aggregate behavior of the sample.

Emissions Impacts

Travel behavior has important impacts on environmental quality, especially on emissions and air quality.

TABLE 2 Multinomial Logit Model Parameters for School Bus, Walk, and Bike Modes, with Automobile as Base Mode

Variable	Bus		Walk		Bike	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
Constant	-1.054	-6.44	2.385	2.40	-1.301	-3.87
Annual household income (in thousand dollars)			-0.0334	-3.33		
Per capita auto ownership for the household			-4.570	-3.61		
License ownership indicator (1 if the individual holds a drivers license, 0 otherwise)	-2.513	-4.23				
Walk time for the trip (in minutes)			-0.0527	-3.98		
Bike time for the trip (in minutes)					-0.1504	-4.07
Average sidewalk coverage for origin and destination zones			1.480	2.09		
Average home-based other accessibilities for origin and destination zones	-1.130	-2.37				

Restricted log-likelihood	-982.9
Log-likelihood with constants only	-493.9
Log-likelihood at convergence	-425.4
Pseudo-R^2	0.139
Number of observations	709

TABLE 3 Point Elasticity Estimates from the Multinomial Logit Model

Variable	Bus	Walk	Bike
Annual household income (in thousand dollars)		-0.84	
Per capita auto ownership for the household		-1.16	
License ownership indicator (1 if the individual holds a drivers license, 0 otherwise)	-0.91		
Walk time for the trip (in minutes)		-0.66	
Bike time for the trip (in minutes)			-2.63
Average sidewalk coverage for origin and destination zones		0.42	
Average home-based other accessibilities for origin and destination zones	-0.31		

Therefore, as a final step, the vehicle emissions impacts were estimated for different school locations and built environments.

To illustrate the emissions impacts of school location and the built environment, emissions were estimated for two schools from the Gainesville sample. The preferred choice model then simulated the travel and emissions differences between the Gainesville sample and an alternative of neighborhood schools with complete sidewalk networks.

High Schools Comparison

Gainesville High School is centrally located and surrounded by development; Eastside High School is located at the edge of an urbanized area amid undeveloped land. The mode split at Gainesville High School is 85 percent automobile, 13 percent walking, and 2 percent biking. Eastside High School had 100 percent automobile use. Gainesville High School students who drove had an average trip about half as long as that of Eastside students.

Vehicle emissions were estimated for each school; Table 5 presents the results. Although the samples were small, the following observations can be made:

- Longer automobile trips and higher automobile mode shares contributed to emissions that were more than twice as high for sampled Eastside students as for their Gainesville counterparts, and
- The longer average trip for Eastside students—twice that of Gainesville students—contributed more to the higher emissions than did the higher automobile mode split.

Neighborhood Schools Simulation

The best-fit model was applied to simulate mode choice probabilities for a scenario with neighborhood-based schools and complete sidewalk networks. Results were compared with the actual mode choices for the Gainesville sample.

In the scenario, neighborhood schools allowed for a 10-minute walk and a 2.5-minute bike ride—travel times for a distance of 0.5 miles at 3 mph and 12 mph, respectively. All arterials and collectors were assumed to have sidewalks. All other variables were held constant.

TABLE 4 Base Mode Share and Simulated Mode Share with a 25 Percent Change in Each Independent Variable

Variable	Change	Car	Bus	Walk	Bike
Base mode share	—	77.3	14.8	4.5	3.4
Annual household income (in thousand dollars)	-25%	76.2	14.6	5.9	3.2
Per capita auto ownership for the household	-25%	75.8	14.5	6.5	3.2
Walk time for the trip (in minutes)	-25%	76.5	14.7	5.5	3.3
Bike time for the trip (in minutes)	-25%	76.5	14.7	4.5	4.4
Average sidewalk coverage for origin and destination zones	-25%	77.9	14.9	3.7	3.5
Average home-based other trips for origin and destination zones	-25%	76.5	15.7	4.5	3.4

Values may not total 100 percent because of rounding.

TABLE 5 Emissions for Travel to or from Two High Schools

	Mode		Trip Length	Emissions/day, grams			
	Auto	Nonauto	Average Auto, mi.	VOC	CO	NO_x	CO_2
Gainesville	85%	15%	4.24	15,472	191,931	12,894	5,936,186
Eastside	100%		8.42	36,147	448,408	30,123	13,868,670
Eastside/ Gainesville	1.18		1.98	2.34	2.34	2.34	2.34

VOC = volatile organic compounds; CO = carbon monoxide; NO_x = oxides of nitrogen; CO_2 = carbon dioxide

TABLE 6 Base Mode Shares, Simulated Mode Shares, and Mode Share Changes with a Neighborhood Schools Scenario

Variable	Base	Simulation	Simulation/ base
Car	77.3%	66.0%	85%
School Bus	14.8%	12.7%	86%
Walk	4.5%	10.3%	229%
Bike	3.4%	11.1%	326%

Values may not total 100 percent because of rounding.

The reductions in walk and bike times and the increase in sidewalk coverage caused a significant shift in mode shares (Table 6). The percentage of students walking to school more than doubled, from 4.5 to 10.3 percent of all trips. The percentage of students biking to school almost tripled, from 3.4 to 11.1 percent. Together, the nonmotorized mode share increased from 7.9 to 21.4 percent.

The results are consistent with the earlier simulations. Gainesville students' travel preferences show that they would bike and walk in substantial numbers if the distances were kept short enough.

The emissions impacts of such a shift were estimated from national values for school bus average trip length (6.8 miles, according to the 1995 NPTS) and student loads (25 per bus). National averages from U.S. EPA's mobile source emission model, MOBILE 6, yielded estimates for school bus emissions. Automobile trip distances were set at the Gainesville sample average, 4.82 miles. Finally, an enrollment of 400 was assumed for the neighborhood school, although the assumption made no difference in the relative results.

The simulated neighborhood schools reduced emissions by 14 to 15 percent. The reductions were not uniform because of the different emissions profiles of school buses and personal vehicles (see Table 7). This simulation probably underestimated the change in emissions by assuming fixed distances for automobile and school bus trips.

Implications of Findings

In this study, students with shorter walk and bike times to school proved to be more likely to walk or

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bike. If confirmed through subsequent research, this finding argues for neighborhood schools that serve nearby residential areas.

Students traveling through areas with sidewalks on the main roads also were more likely to walk. If confirmed, this finding argues for Safe Routes to School sidewalk improvements.

The study also determined that centrally located schools to which students can walk or bike would reduce vehicle emissions significantly. If confirmed, this finding adds one more rationale for small neighborhood schools over megaschools on large outlying sites.

The findings are only partly consistent with earlier studies of school mode choice. Two previous studies found distance from home to school to be significant, a result confirmed by this study. Elements of the built environment around a school also were found to be significant, as in this study.

The characteristics of the built environment that influence school mode choice, however, remain an issue. Neighborhood population density proved important in one earlier study; street tree coverage in the vicinity of a school was important in another study; and age of schools—which can be related to traditional neighborhood design, higher density, and finer land use mix—was important in a third study. None of these variables proved significant in this study, which indicated instead that sidewalk coverage was

TABLE 7 Emissions Levels for Base Case and Neighborhood Schools Simulation

	Emissions/day, grams			
	VOC	CO	NO_x	CO_2
Sample mean	3,907	43,202	13,043	2,599,545
Simulation	3,338	36,894	11,180	2,225,186
Simulation/Sample mean	0.85	0.85	0.86	0.86

Photo: Dan Burden, Walkable Communities, Inc.

significant—a result not previously documented.

The role of school size in travel mode decisions also requires further study. Student enrollment proved significant in one earlier study of mode choice, but not in this study, which included controls for travel time to school. Whether school size has a direct effect on school mode choice, beyond the indirect effect on travel time to school, therefore, remains an issue.

The implications of these and similar results for planning practice are clear. School siting decisions are among the most important and expensive investments that communities make. The decisions have an impact not only on core educational goals, but also on issues of community growth and development, urban form, and public health.

The study results indicate that large schools on remote sites may have the same negative travel and emissions consequences as other more generally recognized forms of sprawl. Planners may want to work with educational policy makers to discourage this practice.

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